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Maritimes Region

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Science Advisory Report 2011/057

CONSIDERATIONS FOR THE ESTIMATION OF INCIDENTAL CATCH IN THE EASTERN CANADIAN SWORDFISH/OTHER TUNAS LONGLINE FISHERY

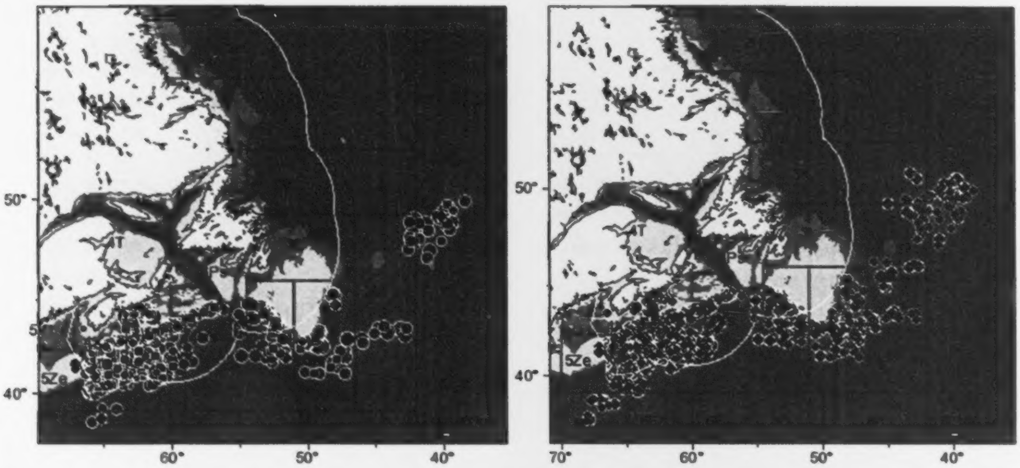

Figure 1: The Northwest Atlantic, showing the distribution of Observed swordfish/other tunas longline sets (left panel) and all commercial swordfish/other tunas longline sets (right panel) between 2002 and 2010. Dark lines indicate North Atlantic Fisheries Organization Subdivisions, and the white line indicates the Canadian Exclusive Economic Zone.

Context:

The Canadian swordfish and other tuna longline fishery directs for swordfish and other tunas (yellowfin tuna, bigeye tuna and albacore) throughout the Canadian Atlantic Exclusive Economic Zone and beyond (Fig. 1). In 2011, there are 77 longline licence holders that could potentially fish pelagic longline gear. Approximately 35 vessels are expected to participate in the 2011 longline fishery.

The Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries addresses the estimation of the bycatch and discard in Canadian large pelagic fisheries focusing on the swordfish/other tunas longline fishery at this time. The focus of this plan is directed toward seven key species: bluefin tuna (Thunnus thynnus), porbeagle (Lamna nasus), shortfin mako (Isurus oxyrinchus), blue shark (Prionace glauca), leatherback sea turtle (Dermochelys coriacea), loggerhead sea turtle (Caretta caretta), and swordfish (Xiphias gladius).

The principal objective for the swordfish/other tunas longline at-sea Observer program is to collect representative information on the amounts and species composition of landed and discarded species. The program is also used for compliance monitoring; Observer coverage can be increased in a targeted manner for enforcement purposes. It is a condition of license for fish harvesters to carry an Observer should one be deployed to a given trip. Fish harvesters are required to indicate their intention to go fishing six hours prior to departure. In principle, this should facilitate obtaining a random sample of fishing trips for Observer coverage. Target coverage levels for the fishery were 5% until 2008 and 10% for 2009 and 2010.

To document incidental catch taken by this fleet, the fleet had Observer coverage ranging from >25% of sea-days in 2002 to 5-8% during 2004 to 2008. More recently, coverage rates averaged about 11% in 2009 and 2010. A Regional Advisory Process (RAP) meeting was conducted in 2000 to review approaches for the calculation of dead discards of swordfish and bluefin tuna by this fleet (Stephenson 2000). Given that the fishery has evolved considerably over this time, and there is a desire to provide more comprehensive information on the incidental catch taken by this fishery, a RAP was convened to review progress on certain objectives contained in the Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries.

SUMMARY

- The existing Observer Program provides critical information on the catch composition of the swordfish/other tunas (yellowfin tuna, bigeye tuna and albacore) longline fishery. This information is currently used for estimating bycatch and discards. The Regional Advisory Process (RAP) confirmed the utility of this information but concluded that various modifications are required to improve the quality of the advice.

- The eastern Canadian swordfish/other tunas longline fishery is in a period of reduced effort that began in 2007 (although landings have not declined).

- Under the existing target at-sea Observer deployment scheme, fishing trips should have roughly an equal probability of being selected to carry an at-sea Observer. Analyses presented at the RAP indicated that this is not the case.

- It was recommended at the RAP that there be a separate process to evaluate dead discard estimation methods for bluefin tuna, swordfish, shortfin mako, porbeagle and blue shark.

- A review of available methods for assessing post-release mortality was completed. Of the currently available methods, it was concluded that the combination of field observations using standardized release codes validated with satellite tags offers the most informative results concerning survival of released incidental catch.

- Among the species considered at this meeting, the highest priorities for studies of post-release mortality were thought to include porbeagle and loggerhead sea turtle.

INTRODUCTION

Incidental bycatch and discarding of non-targeted species occur in many fisheries. Discarding of targeted species also occurs for a variety of regulatory reasons, e.g., undersized fish, licence restrictions, etc. An objective of an Ecosystem Approach to Fisheries Management is to address incidental mortality for non-targeted species and to manage discard mortality for targeted species. This requires a comprehensive plan for monitoring fishing activity, estimating the amount of discarded individuals and their fishing-related mortality, and establishing suitable references to indicate when that mortality is unacceptable. Currently, DFO has monitoring in place through the Observer Program, Dockside Monitoring Program, and Vessel Monitoring System (VMS). Further, as bycatch concerns were identified, the swordfish/other tunas longline fleet took a number of steps to mitigate bycatch in the fishery.

The Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries addresses the estimation of the bycatch and discard in Canadian large pelagic fisheries focusing on the

swordfish/other tunas longline fishery at this time. Other tunas are defined as bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*), and albacore (*Thunnus alalunga*). The focus of this plan is directed toward seven key species: bluefin tuna (*Thunnus thynnus*), porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and swordfish (*Xiphias gladius*).

Of the seven species of interest for this work plan, six have been assessed at some level of risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Bluefin tuna, loggerhead sea turtle, leatherback sea turtle and porbeagle were all assessed as Endangered. Shortfin mako was assessed as Threatened and blue shark was assessed as a species of Special Concern. Only leatherback sea turtle is listed under the *Species at Risk Act*.

The Workplan is organized into projects under three main themes: 1) level of Observer coverage, 2) manage discards for all targeted species, and 3) control incidental mortality for non-targeted species.

Fisheries and Oceans, Maritimes Region, has moved forward with projects considered highest priority with respect to available resources. Three projects were to be reviewed in this Regional Advisory Process (RAP) meeting:

- Level of Observer coverage: estimates of precision (1A).
- Discard estimation: evaluation of data, methods & results for estimating discards (2.1A).
- Survival of released bycatch: review methods for determining post-release mortality (2.2A).

ANALYSIS

Level of Observer Coverage: Estimates of Precision

> <u>Describe the evolving fishery patterns of the swordfish/other tunas longline fishery, summarize their Observer coverage and determine the nominal estimates of precision for the discard:effort and discard:landed ratios of each of the seven study species (bluefin tuna, porbeagle, shortfin mako, blue shark, leatherback sea turtle, loggerhead sea turtle and swordfish).</u>

The eastern Canadian swordfish/other tunas longline fishery is in a period of reduced effort that began in 2007 (although landings have not declined). There were fewer active vessels in 2010 and fewer sets, trips and sea days than in 2006. All areas have shown this decline with the exception of 5ZY6DE which experienced increased effort, although landings in that area are comparatively small. East of 60° west longitude the fishing dropped by 75% and in 4WX effort dropped by 50%. The decline was most noticeable in the smaller vessel classes examined.

Data from 2002 to 2010 were used in the analyses. There were higher levels of Observer coverage in 2001, however those data were not examined, due to problems with matching Observed trips with logbook data. The precision of ratios used to scale bycatch to the whole fleet was evaluated for the existing sampling design with a view to recommending practical alternative sampling schemes and target levels of Observer coverage for seven study species (bluefin tuna, porbeagle, shortfin mako, blue shark, leatherback sea turtle and loggerhead sea turtle).

Inferring the amount of discarded fish in a fishery using at-sea Observer sampling assumes that observed activities directly or conditionally (given some sort of adequate model, such as stratification) approximate a random sample of all activities. If this assumption is violated, any inference made will be potentially biased and its precision is likely to be overestimated (Cotter and Pilling 2007).

Under the existing target at-sea Observer scheme, fishing trips should have roughly an equal probability of being selected to carry an at-sea Observer. Analyses presented at the RAP indicated that this is not the case. Though spatial and temporal target and realized levels of Observer coverage did concur in many instances, there were areas and time periods of considerable fishing effort that were not observed (Fig. 2). For example, the western area (4X, 5Z) appeared to be undersampled by the Observer deployments, whereas the Grand Banks appeared to be oversampled in some years. Larger vessels, as well as small vessels making longer duration trips were disproportionately sampled by Observers. There may also be other unknown structural biases in Observer deployment (e.g., Benoît and Allard 2009). In the case of the swordfish/other tunas longline fisheries, post-stratification of the data during analysis can serve to reduce the consequences of non-random deployment for known important sources of sampling bias. However, it is not possible to correct for unknown structural deployment biases.

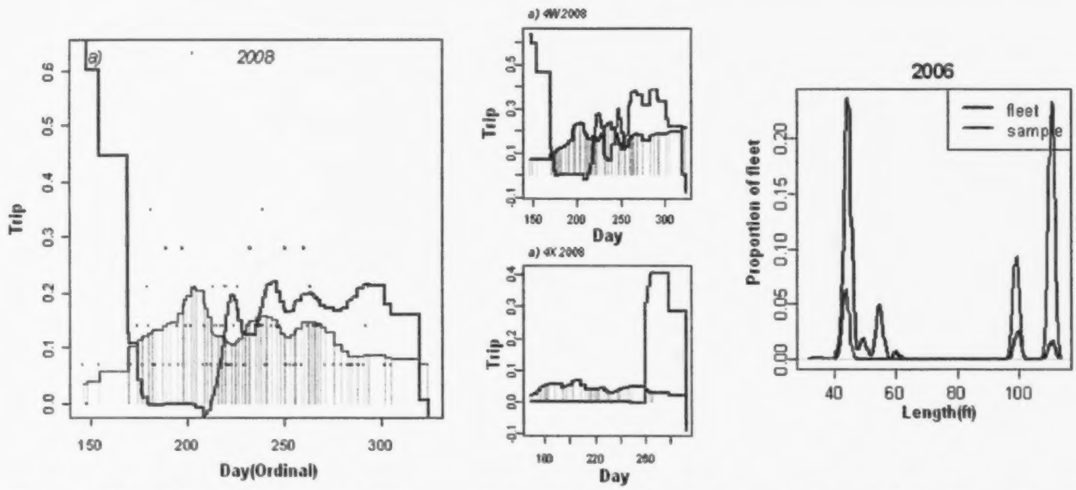

Figure 2: Plot of the loess smoothed Observed trips (red) relative to optimally sampled fleet trips (black) by day of year (left) for 2008. Similar plots are shown for areas 4W and 4X in 2008 (middle). The coverage of the vessels prosecuting the fishery relative to those Observed is shown relative to vessel length (right) for 2006.

<u>Investigate sampling implications of practical alternative stratification schemes.</u>

Science advice derived from Stephenson (2000) may have constrained the sampling too much. The sampling scheme in that document recommended that to have adequate sampling coverage providing a more precise estimate of dead discards from the swordfish longline fleet than that obtained with the previous 5% Observer coverage, the coverage should be in the order of 10–15% (minimum, one trip per month per area (Scotian Shelf East and West of 60° West, Grand Banks) in the spring and fall, with two to four additional trips during the peak of the season in July to September). The sampling did not always appear to represent the fishing activity well, especially when coverage was near 5%. However, the sampling design was not updated to accommodate the lower level of Observer coverage.

The current sampling strategy could be improved and made more practical if careful consideration were given to clearly defining the objectives. Clear objectives on preferred sampling strategies including target levels for precision of the estimates of bycatch should be developed.

Where possible, a real time or near real time evaluation of the progress of the sampling should be conducted so that in-season adjustments can be made to the allocation of Observer time. Better communication between DFO Science and the Observer contracting company is required so that guidance can be provided when changes to the sample strategy are required.

While the RAP did not evaluate alternative schemes to stratify the data, it was noted that to avoid significant bias, further stratification of the data may be required (by area, season, target). However, such investigations may be limited by the available Observer data.

> Evaluate the utility of the higher Observer coverage conducted in 2001-2002 with respect to quantifying the improvement in precision.

A simulation of the effects of increasing Observer coverage on the precision of estimates of bycatch for the seven species of interest was performed. Precision of an unbiased estimate does improve with higher levels of Observer coverage. Specific objectives for precision need to be established on a species-specific basis. Following that, further work would be required to determine Observer coverage levels to achieve these objectives. Again, the RAP noted that the approach could potentially benefit from disaggregating the data into time/area strata.

> Review the applicability and results of various bycatch reporting methodologies for achieving desired precision of estimated discards.

The previous RAP (Stephenson 2000) concluded that a ratio-based approach for bycatch estimation would be the best approach at that time. Alternatives for scaling the Observed bycatch to the entire fishery were considered during the current RAP meeting. To further evaluate this, both effort-based and landed-weight-based auxiliary variables were tested using simulation to see which afforded the greatest precision. Increases in the sample fraction (coverage) did improve the precision but not for every species and every combination of auxiliary variable. Some auxiliary variables provided improved precision but not consistently. Precision varied by year for all estimators. It was observed that the relationship between the auxiliary variable and the discard variable did not always justify the use of the ratio estimation method. Additional work is required.

Discard Estimation

> Conduct a comparative evaluation of the data, methods and results for estimation of total (live+dead) discard of bluefin tuna, swordfish, porbeagle, shortfin mako and blue shark.

Most Regional Fisheries Management Organizations (RFMOs), including the International Commission for the Conservation of Atlantic Tunas (ICCAT), estimate discards by calculating the weight ratio of the discard species relative to the target species, and then scaling to the total reported landings of the target species. Discard calculations for porbeagle, shortfin mako and blue shark were similarly estimated, but stratified by fishing quarter and fishery. Alternative strata may be required for other discard species, such as swordfish. Preliminary analyses indicated that there was no trend in shark bycatch discard ratios across years, allowing the use of a mean ratio for each quarter and fishery, but further analysis is required.

The accuracy of the discard weight ratio method to estimate total species bycatch can be tested for high value discard species such as shortfin mako. Total estimated shortfin mako retained catch based on scaled Observer observations from all sources and fisheries averaged 90% of total reported landings, indicating that the method can provide reasonable estimates of scaled total bycatch for some species. Similar tests of accuracy for other species (such as porbeagle) are recommended.

A comparative evaluation was not done for bluefin tuna and swordfish. It was recommended at the RAP that there be a separate process to evaluate dead discard estimation methods for these species.

Recommend best practices specific to the swordfish/other tunas longline fishery.

Best practices more generally related to the estimation of bycatch were not reviewed in this meeting, but have been reviewed in other fora (Cotter and Pilling 2007, ICES 2000, Rochet and Trenkel 2005). Furthermore, no conclusions were reached on best practices related to ratio estimators, and the RAP did not evaluate the relative merits of design-based versus model-based estimation.

Given that the swordfish/other tunas licence holders are able to catch swordfish with either longline or harpoon gear, it is recommended that discard calculations for the longline fishery have the harpoon component removed. The method that excluded the harpoon catch selected for the correct licence types and gear and also excluded records whose effort amount in hooks was less than 10. For estimation of bluefin tuna dead discards, it was recommended that trips which had unused bluefin tuna enforcement tags available be accounted for in the calculation.

Survival of Released Bycatch

Review methods for determining post-release mortality.

A review of available methods for assessing post-release mortality was completed. The methods can be grouped into five classes, including confinement (i.e., holding animals in aquaria), field observations (i.e., at-sea Observers), conventional tagging, telemetry (including both acoustic and satellite tagging approaches), and physiological correlates of mortality (i.e., blood chemistry indicators such as lactic acid or cortisol levels). Based on the review, best practices for determining post-release survival in the Canadian swordfish/other tunas longline fishery were recommended, focusing on the seven species of particular interest to the RAP.

Develop guidelines for best practice when determining total dead discards from fisheries, but in particular from swordfish/other tunas longline fisheries.

Of the currently available methods, it was concluded that the combination of field observations using standardized release codes validated with satellite tags offers the most informative results concerning survival of released incidental catch (e.g., Campana et al. 2009). Studies of this nature have been completed for blue shark, and for a recreational fishery for bluefin tuna in the southern Gulf of St. Lawrence through the International Governance Strategy (IGS). That program has also funded upcoming studies for loggerhead sea turtle and porbeagle.

Based on conservation considerations and the available research, the RAP prioritized the seven species of interest (Table 1). Among the species considered at this meeting, the highest priorities for studies of post-release mortality were thought to include porbeagle and loggerhead sea turtle. The priorities were assigned considering the availability of information on post-

release mortality, the available information on stock status, and the scale of the discards in relation to the catch.

Table 1: Prioritization of the need for studies of post-release mortality for the seven species examined. The assignment of priority was subjective, but considered the availability of information from completed studies, stock status, and the scale of the discards in relation to the catch.

Bycatch Species and Stock	Priority	Comments
West Atlantic bluefin tuna	Medium. Study* completed in southern Gulf of St. Lawrence (GSL)	Relatively small bycatch, but stock status is controversial. Results from GSL apply to that recreational fishery only.
North Atlantic swordfish	Low	Rebuilt stock, discards relatively small compared with landings. Existing pop-up satellite archival tags (PSAT) results* may give some insight, although not designed for post release mortality estimates specifically.
Shortfin mako	Medium	Discards are comparable to landings in some fisheries, so post-release mortalities could influence view of stock status.
Blue shark	Low, work already completed	See Campana (2009)*. Could change priority if there is a need to resolve differences with other blue shark studies.
Porbeagle	High	Discards exceed landings; PSAT-based study* to commence in 2013.
Loggerhead sea turtle	High	Three year PSAT-based study* to commence in 2011.
Leatherback sea turtle	Low	2006 Leatherback Sea Turtle Recovery Plan suggests that mortalities are low. Recovery strategy scheduled for update in early 2012, COSEWIC reassessment scheduled for April 2012.

* Funded in total or in part through the International Governance Strategy.

Leatherback and loggerhead sea turtles are bycatch species of particular interest given conservation concerns and international obligations. Using Observer data from 2001-2009, bycatch rates of leatherback and loggerhead sea turtles were examined. It is clear that catches of turtles are highly clustered by space (Fig. 3) and time, thus creating difficulties for modelling the effects of factors that influence the catch of turtles. This work should be pursued further.

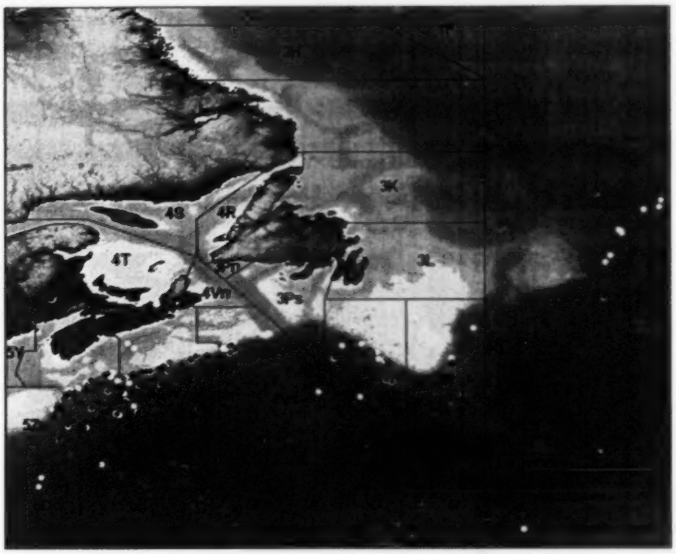

Figure 3: Encounters of leatherback and loggerhead sea turtles in the Canadian swordfish/other tunas fishery, as indicated from Observer information from 2001 to 2009.

Sources of Uncertainty

Quantifying the amount and species composition of animals discarded in a fishery is not straightforward when Observer coverage is incomplete (i.e., a survey rather than a census) because the characteristics of fishing activities taking place in the absence of an Observer must be inferred from the characteristics of observed activities. Such inferences assume that observed activities directly or conditionally (given some sort of adequate model) approximate a random sample of all activities. If this assumption is violated, any inference made will be potentially biased and its precision is likely to be overestimated (Cotter and Piiling 2007). This may occur for two general reasons (Benoît and Allard 2009). The first, is a non-random assignment of Observers among sampling units (vessels, trips, or individual fishing sets), and was addressed at the RAP. The second is a change in fishing behaviour when Observers are present, often called an Observer effect. This was not considered at the meeting. An Observer effect can occur for many reasons: skippers may fish at nontraditional sites, modify their fishing effort, operate their gear differently, or retain fish that would otherwise have been surreptitiously discarded. Bias in the discards amounts estimated using at-sea Observer data increases with the extent to which normal fishing behaviour is modified by Observer presence. While methods exist to assess whether there may be Observer effects in at-sea Observer survey data, estimating the bias that results is unlikely to be possible in most circumstances.

CONCLUSIONS AND ADVICE

The existing Observer Program provides critical information on the catch composition of the swordfish/other tunas longline fishery. This information is currently used for estimating bycatch and discards. The RAP confirmed the utility of this information but concluded that various modifications are required to improve the quality of the advice. Such changes could include in-season review of actual deployments in relation to the sampling design, species-specific sampling schemes that recognize temporal and spatial population boundaries, periodic review

of the sampling design, documentation of objectives, a clear definition of the bycatch precision targets, and better communication between DFO Science and the Observer contracting company. The development of the Observer sampling scheme requires extensive coordination among multiple sectors and industry, led by Fisheries Management Branch.

In the collection of the data, alternative methods of measurement have been proposed. It is recommended that DFO continue to explore these alternatives including video-based monitoring, Fishers Self-Sampling Programmes and the use of VMS data for estimating fishing effort.

To improve the quality of field observations on condition of released incidental catch, it is recommended that DFO work with industry, the Observer contracting company and other stake-holders to develop standards that will help Observers more consistently categorize release condition. This initiative could include photographs as part of a revised field manual. The most appropriate methods for determining post-release mortality would involve a combination of field observations as described above, as well as survival information from satellite archival tag studies, implemented during regular fishing operations.

Among the species considered at this meeting, the highest priorities for studies of post-release mortality were thought to include porbeagle and loggerhead sea turtle. DFO plans to undertake such work on porbeagle by 2013, and on loggerhead sea turtle starting summer 2011.

Additional work will be required to deal with issues in the Terms of Reference that this RAP was not able to complete. It was recommended at the RAP that there be a separate process to evaluate dead discard estimation methods for bluefin tuna, swordfish, shortfin mako, porbeagle, and blue shark. Key additional issues include development of best practices for dead discard estimation, and appropriate Observer coverage levels taking into account requirements for each bycatch species.

Although the Terms of Reference specified an analysis of precision, it was noted that bias and accuracy are as important as precision (e.g., an estimate could be very precise, but biased). It was recommended that analyses of the accuracy of the estimates be conducted.

It was noted that the Work Plan to address Incidental Catch in the Canadian Large Pelagics Fisheries is a "living" document. It is recommended that it should be adjusted to focus on gaps. The RAP recommended an examination of other Canadian Atlantic fisheries both targeting large pelagic species (e.g., bluefin tuna and shark) and taking large pelagic species as bycatch (e.g., herring purse seine, mackerel trapnet, herring gillnet and groundfish fixed gear). This examination should review available data for the various fisheries, outline where no data are available and make recommendations to fill these gaps. Recommendations should include appropriate Observer coverage levels on a fishery-by-fishery basis.

SOURCES OF UNCERTAINTY

Quantifying the amount and species composition of animals discarded in a fishery is not straightforward when Observer coverage is incomplete (i.e., a survey rather than a census) because the characteristics of fishing activities taking place in the absence of an Observer must be inferred from the characteristics of observed activities. Such inferences assume that observed activities directly or conditionally (given some sort of adequate model) approximate a random sample of all activities. If this assumption is violated, any inference made will be potentially biased and its precision is likely to be overestimated (Cotter and Pilling 2007). This

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SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of July 11-12, 2011, on Considerations for the Estimation of Incidental Catch in the Eastern Canadian Swordfish/Other Tunas Longline Fishery. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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